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Evolution Study of Colours Throughout the History of Façades of the Royal Ordnance Factory of Seville

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Abstract

A study of the superimposition of the colours on the Royal Ordnance Factory of Seville provides information about the history of this monument. The façades, lanterns and domes are painted with a combination of pure white, reds and yellows. This palette is characteristic of the city of Seville. This study revealed the presence of lime and iron oxide pigments.

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1. Introduction

The term “colour” may refer not only to a certain region of the visible light spectrum but also to the materials in pigments and dyes, or, frequently, be used as a synonym for pigment or paint. Knowledge of the range of colours produced by light and pigments in the buildings of a city is necessary to understand life in the city during various time periods. Prior to the 19th century, decoration of façades was a characteristic architectural element in the Spanish city of Seville. The Royal Ordnance Factory of Seville, which is a complex structure with many different sections, is an example of industrial architecture in Seville. The section known as “The Cathedral” (see Figs. 1 and 2) is a spectacular

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space designed in the service of industry. Many analytical techniques have been developed and applied to identify the pigments or painting materials used in ancient polychrome [1,2,3].

The objective of this work was to study the various colours on the façades, lanterns and dome of the Royal Ordnance Factory of Seville during different periods of history. Restoration of the façade of the Royal Ordnance Factory of Seville will focus on recovering much of this ornamentation.

History and location of the paintings analysed in the Alcázar.

The Royal Ordnance Factory was built in the city of Seville by master founder Juan Morel. However, none of the original structures remain. In 1717, the factory was managed by artillery officers of the Spanish Army. A new industrial complex based on the modern manufacturing of French Colbertism was introduced at the same time. The oldest structure in the factory, known as the "Old Foundry", was constructed by Juan Navarro in 1717. The most important building of the factory was commissioned from Jorge P. Verbom by King Felipe V in 1725. In 1757, the engineer Juan M. Porres added the building known as "The Cathedral," which was based on the original modular system of Verboom and Sala. Porres's work was continued in 1767 by the Swiss engineer Jean Maritz. The Royal Ordnance Factory was used until 1991.

2. Materials

Overlapping layers of colours in different sections of the building have been studied in the historical context of the monument. Planimetric studies were conducted, and an historical study based on the analysis of bibliographic sources, iconography, photography, models, etc. was performed. Several small samples were taken for the laboratory study.

3. Techniques

The chromatic characterization was determined *in situ* using a portable spectrometer. A xenon lamp producing approximately normalized D65 light was used for the colour measurements. The tristimulus values of the examined surfaces were measured in CIE coordinates (L*, a^*, b^*). The L*, a^*, b^* space has been defined by the International Commission on Illumination (CIE) as a uniform colour space. Cross-sections of the samples were prepared based on the methods of Khandekar [4]. The cross-sections were examined using optical microscopy (Nikon HOPTIHOT). Different analytical techniques were employed to study the sequence of the layers. The cross-sections were examined using a HITACHI S-4800 scanning electron microscope (SEM). Elemental chemical analyses of the cross-sections were performed using a Link ISIS energy dispersive X-ray (EDX) analyser coupled with the SEM. X-ray diffraction (XRD) patterns were collected using a Panalytical diffractometer X`Pert Pro MPD. Simultaneous TG-DTA measurements (STDQ600, TA Instruments) were also performed.

Fig. 1. Section known as "The Cathedral".

Fig. 2. Roof of "The Cathedral".

4. Results and discussions

The CIE coordinates of the surface colours and the Munsell colours determined in the dome are included in Table 1. The L* values are the highest in layers 02 and 04. These layers were deposited on two white layers that lost some of their intensity with time. Layer 02 contains a reddish-orange colour and a pink colour. The latter has a greater L* value due to its position on the white layer and the effects of ageing. Similar results were obtained for layers 04 and 05. The loss of colour in some zones of layer 02 does not result in large differences between the two colours. The a* value of 17 indicates red and the b* values of 20 and 21 indicate yellow. Layers 04 and 05 have important differences. The a* value for layer 04 indicates more green (less red) than layer 05. The b* values for layer 05 indicate more yellow (less blue) than layer 04.

Conventional optical microscopy was utilized to examine the cross-sections of the paints found in the wall paintings of the monument. A selection of micrographs of the cross-sections is shown in Figure 3.

Sample C001 has a yellow colour on the surface followed by white. The EDX analysis of the yellow layer indicated the presence of Ca in the form of calcite and a small amount of Si and Al. The presence of iron suggests that the yellow colour was obtained using iron oxide. The layer of white colour is comprised of calcite. Both layers contain lime. The external layer of sample C001B has an ochre colour. The chemical analysis of this layer showed the presence of Ca and S, in the form of gypsum. Environmental contamination may also be responsible for the ochre colour. The white layer of this sample is comprised of calcite with lime.

Samples C001C and C0011D have two calcite layers. Samples C001F and 003 are comprised primarily of Ca, but contain nodules made of quartz (Si and O) and feldspars and mica (Si, Al, Fe and K). A lime mortar and an inert material containing quartz, feldspars and mica are present. The surface layer of these samples contains-calcite. Sample C004 has a reddish colour containing Ca and Fe. XRD was used to characterize the minerals present in the different layers of the wall paintings, and the semi-quantitative analyses are shown in Table 2 [5]. Calcite and organic compounds are present in all samples, primarily sample C001B and the while colour of sample C001, due to environmental contamination.

The proposed changes in the colour of the façade and dome over time are shown in Figures 4 and 5.

Table 1. L*, a*,b* and NCS colours of the dome.

Layer	Colour	L*	a*	b*	NCS colour
02	pink	61.49	17.38	20.48	S 1030 Y90R
02	red orange	54.29	17.63	21.95	S 2070 Y80R
04	light yellow	71.42	8.65	28.92	S 1020 Y20R
05	light ochre yellow	56.45	15.18	36.64	S 3060 Y20R

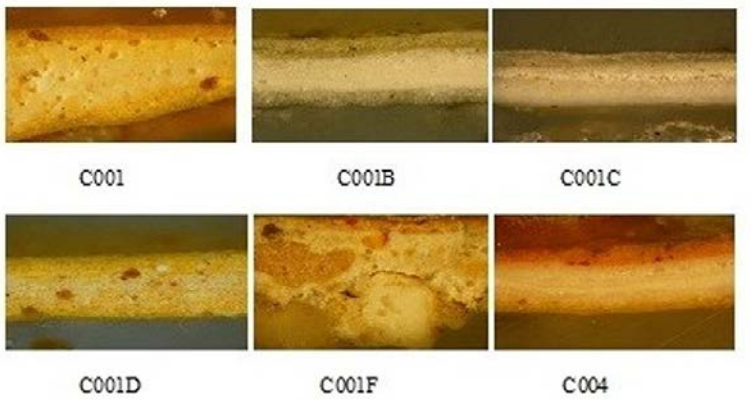

Fig. 3. Optical micrographs of the colour cross-sections studied in this work.

Table 2. Quantitative estimation (%) of the mineral phase content in the studied samples using XRD, DTA/TG, FTIR, SEM and EDX.

Sample	$CaCO_3$	Organic component	Quartz	Feldspars	Gypsum
C001 white	66.65	4.00	<5	<5	28.15
C001 colour	13.80	6.00	10	<5	3.60
C001B	50.06	0.36	10	<5	39.00
C001 C	75.87	3.70	<5	<5	17.96
C001D	73.72	4.50	10	<5	4.50
C001F	64.00	4.00	20	<5	9.41
C003	52.63	2.00	25	10.00	8.85
C004	98.00				

5. Conclusions

This research work shows that the Royal Ordnance Factory of Seville has a red and yellow colour palette on its façade. These colours are characteristic of the city of Seville.

Scientific analysis allows characterization of the chromatic treatments over time. The main structural elements, cornices and pilasters were initially painted with red and white colours, reinforcing the architectural composition of the façade. Later, the walls were painted yellow, while the structural elements, cornices and pilasters remained red. During the third stage, the cornices and pilasters were painted white and yellow, and these colours have survived until the present day. Pigmented lime, iron oxides, and clay minerals are present. Gypsum, from environmental contamination, was also detected.

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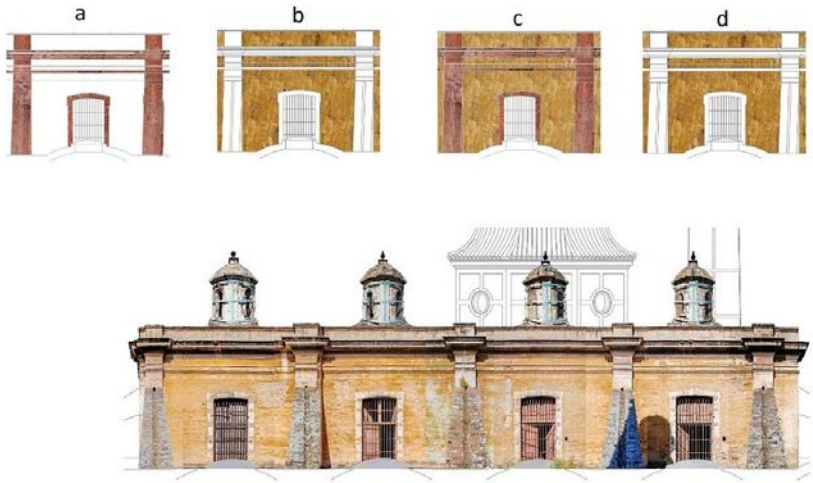

Figure 4. Hypothesized colour of the façade from its construction to the present day: a) (state 01), base: white colour, pilaster: red ochre, cornice: red ochre, b) (state 02), base: yellow colour, pilaster: white cornice: white, c) (state 03), base: yellow colour, pilaster: red ochre, cornice: red ochre, d) (state 04), base: yellow colour, pilaster: white, cornice: white.

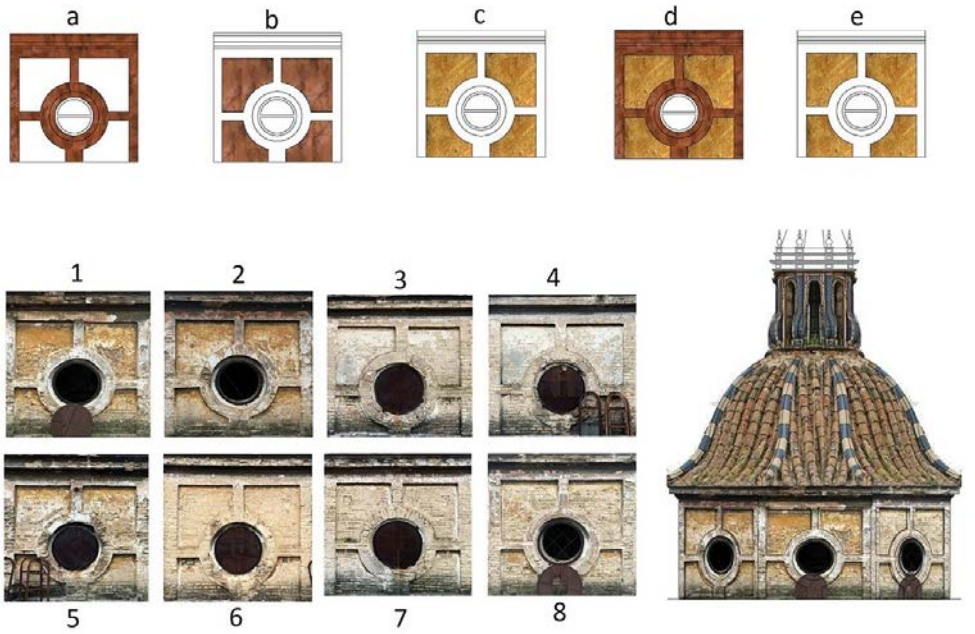

Figure 5. Hypothesized colour of the façade from its construction to the present day: a) (state 01), base: white colour, fence: red ochre, b) (state 02), base: red ochre, fence: white, c) (state 03), base: light ochre yellow, fence: white, d) (state 04), base: light ochre yellow, fence: red ochre, e) (state 05), base: light ochre yellow, fence: white. Colours of the dome façade: 1. North 2. Northeast 3. South 4. Southwest 5. East 6. Southeast 7 West 8. Northeast.

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